Half Quanta.

THE Wilson-Sommerfeld principle when applied to the case of a rotating molecule, supposed rigid, leads to the expression $mh/2\pi$ (m integral, h Planck's constant) for the angular momentum of the molecule, and on this basis, with the help of several other assumptions, it has been found possible to account very satisfactorily for the main features of the structure of band-series. The theory is found to apply not only to ordinary bands in the region of the visible spectrum but also to absorption bands of very different appearance, such as those due to the halogen acids which occur in the infra-red. In the latter case, however, a discrepancy exists which has given rise to a good deal of discussion. The observed bands consist of a number of lines distributed, to a first approximation, according to the formula

$$\nu = \nu_0 \pm m\omega,$$

where m takes successive positive integral values and ω is a constant. The line of wave-number ν_0 (*i.e.* $m = 0$) is invariably absent.

The theoretical expression, on the other hand, is of the form

$$\nu = \nu_0 \pm (m - 1/2)\omega,$$

which, it will be noted, represents a similar set of lines displaced through a distance $\omega/2$. The reality of the discrepancy is therefore dependent upon the correct identification of ν_0, and as this is not entirely beyond question some workers have preferred to take the value indicated by the theory, although by doing so fresh difficulties in the interpretation of the results arise. Einstein, however, pointed out (quoted by Reiche, *Zeitschr. f. Phys.*, 1920, p. 283) that theory and observation would agree if instead of the usual value $mh/2\pi$ for the angular momentum one assumed it to be given by $(m + 1/2)h/2\pi$. The evidence from the infra-red absorption bands seems scarcely strong enough to warrant such a revolutionary change, but other data bearing on the question have recently become available. In the band spectrum of helium, for example, series exist which show this same peculiarity, and here its existence is indubitable, for the normal (*i.e.* theoretical) series are in this case also present, and a trustworthy value for ν_0 can be determined from them.

Following up Einstein's suggestion, I have found that the abnormal series may in all cases be very simply derived from the normal group by displacing the quantum number by one-half. As an illustration of the sort of agreement which is obtained I may cite the case of the $\lambda 5730$ band (see Curtis, Roy. Soc. Proc., 101, 1922, p. 38), which consists of six series, only three of which satisfy completely the theoretical requirements. The "half-quantum series" calculated from these three are as follows:—

$$17436{\cdot}6 - 31{\cdot}5m + 0{\cdot}95m^2$$
$$17436{\cdot}6 + 31{\cdot}5m + 0{\cdot}95m^2$$
$$17436{\cdot}6 + 0{\cdot}95m + 0{\cdot}95m^2$$

The remaining three observed series are represented by the formulæ:—

$$17437{\cdot}3 - 30{\cdot}0m + 0{\cdot}87m^2$$
$$17436{\cdot}8 + 29{\cdot}5m + 1{\cdot}09m^2$$
$$17437{\cdot}3 + 1{\cdot}15m + 0{\cdot}87m^2$$

The correspondence is very close, having regard to the approximate character of the formulæ upon which the calculation is based. It is certainly good enough to justify the proceeding as an empirical method of expressing the relationship between the two groups and to encourage theoretical inquiry into its physical significance.

As the matter stands at present, the inference—illusory though it may be—is that the molecules fall into two classes, according to whether their angular momenta are given by $mh/2\pi$ or by $(m + 1/2)h/2\pi$. Transitions between the two classes do not occur (or, if they do, give rise to no radiation), since there are no lines corresponding to changes of one-half in the quantum number. That is to say, whether or no the half-quantum may be involved in the determination of the possible states of a molecule, it does not appear to play any direct part in the radiation process.

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Fossils in Burmese Amber.

AMBER mines have long been known in Upper Burma, or rather in the adjacent "unadministered tracts." In 1916 Mr. R. C. J. Swinhoe, of Mandalay, began to send me specimens of Burmese amber (Burmite) containing insects. As opportunity has offered, he has continued to obtain such material, all of which has been transmitted, after investigation, to the British Museum (Natural History). Up to the present time I have been able to describe 38 species of insects, three arachnids and one diplopod. Many other species, which I did not feel competent to deal with, or which could not be seen properly, exist in the amber, and will, I hope, eventually be described by others. On the whole, the fauna is very remarkable, containing a large preponderance of types which are usually considered primitive. The amber was said to come from Miocene clay, in which, however, it was presumably of secondary origin. Judging from the fossils, I suggested as early as 1917 that the amber might be actually very much older than Miocene, conceivably even Upper Cretaceous (*Amer. Journ. Sci.*, Nov. 1917, p. 360).

Recently, information has been received which tends to confirm the suspicion that the amber is much older than Miocene. Dr. F. A. Bather of the British Museum has kindly transmitted a letter from Dr. E. H. Pascoe, Director of the Geological Survey of India, dated July 20, 1921. Dr. Pascoe states that Dr. M. Stuart, in his recent journey down the Hukong Valley, saw something of the amber mines, and reported that the shafts were sunk in beds which appeared to be identical with the Tipam sandstone or the Irrawaddy series. Whether they passed through into underlying rocks could not be determined, but from the evidence obtained by Noetling and others it seemed probable that they frequently did. The Tipam sandstone is unconformable on the underlying beds, and frequently contains fragments of them in its lowest horizons. Such fragments may very well include lumps of amber derived from the underlying clays. Dr. Pascoe continues: "Among the debris of some pits sunk into these clays, which are the true home of the amber, Dr. Stuart found a fragment of chalky nummulitic limestone. The pits had been sunk into the clays, not to obtain amber, but flint from the chalky limestone lying in them. Dr. Stuart describes the clays as totally unlike any Disang beds that he had seen, and he is inclined to accept the view that they are Eocene in age. If it is possible to determine the species of the nummulite, I will let you know; but it is, of course, not certain that this nummulitic limestone occurs *in situ* within the clays."

On August 1, 1921, Dr. Pascoe wrote that Dr. Stuart thinks the nummulite is *Nummulites biaritzensis* d'Arch., characteristic of the uppermost zone of the Lower Khirthar. The Khirthars correspond approximately, according to Mr. E. Vredenburg, to the Lutetian. The Lutetian represents the earlier part of the Middle Eocene, below the Bartonian.

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Thus, the evidence seems to indicate that the Burmese amber fauna is Eocene, and older than the Eocene (Bartonian) beds which have produced fossil insects in the south of England.

At this point, however, a new problem is introduced. A few days ago I received from Mr. Swinhoe a number of beads of extremely pale and pellucid amber containing well-preserved insects, all different from those previously described. These insects include a small bee, which seems not to differ at all from the common living Indian *Trigona læviceps* Smith. The other amber contained no ants, but this includes a worker of Crematogaster, workers of Pheidole, and males of Monomorium. I also find a winged termite, a psyllid, a fly of the genus Phlebotomus, some acalyptrate muscoid flies, a mycetophilid, some small spiders, etc. So far as can be seen, this is a modern series of types. Mr. Swinhoe found that the beads, when he purchased them, had been artificially coloured to enhance their value, and he had this colouring matter removed. He learned that several stained necklaces had been imported from China, so he could not be sure that the material was really from Burma. At one time he even wondered whether the specimens could have been included in artificial amber, as is sometimes done. He decided that this last suspicion was unfounded, and I quite agree. His letter ends: "Probably this light amber comes from a locality a few miles off." My own opinion is that this light amber (or copal) is of very recent origin, not earlier than Pleistocene, and contains a fauna which doubtless consists mainly (at least) of species still living. The bee which I recently described as *Meliponorytes* (?) *devictus* probably belongs to this material, and not to the Eocene amber. We may surmise that we have the product of some Dipterocarpaceous tree allied to Vateria; something similar to Miss Ruth Holden's *Dipterocarpoxylon burmense*, based on fossil wood from Burma. More exact information on this matter is greatly to be desired.

T. D. A. COCKERELL.

University of Colorado, May 1, 1922.

Radium Synthesis of Carbon Compounds from Air.

Now that photo-synthesis is attracting special attention it may be interesting to record some recent preliminary experiments on the production of synthetic carbon compounds by the action of radium rays on atmospheric air. Under normal conditions of temperature and pressure, it seems evident that this radio-synthesis is capable of producing carbon compounds apart from living cells, and without the agency of solar radiation.

The experiments arose from an observation, made some nine years ago, during an investigation of the curvature of thin plates of mica when acted upon by radium. After long exposures—some weeks in duration—I noticed a deposit of brown patches, mere specks, on the uppermost side of the thin strips, that is, the side which became concave during α-ray bombardment.

As this deposit was found not to be responsible for the bending, it was not mentioned in the resulting paper (Journal Röngten Society, No. 44, vol. xi., "Alpha Ray Effect Mechanical"), but left for future investigation, which eventually had to be abandoned on account of urgent war work.

Having recently made further experiments, I find that the deposits can be detected more quickly, and better observed, by using freshly drawn fibres of quartz or glass, diameter about 0·04 millimetres. Several of these may be spaced about 1 mm. apart, supported on a framework immediately over the radium salt, about one-eighth of an inch above the uncovered radio-active surface (one or two milligrammes of radium or mesothorium is sufficient).

The whole arrangement should be put into a clean cardboard box (about one litre capacity, to reduce convection currents), with loose fitting lid, which is then put away in a dark room. After remaining undisturbed for a week, it will be seen, using a Coddington lens (or better if transferred to a microscope with one-inch objective), that the fibres are covered with a clear white viscid liquid film, which is beginning to gather up into beads, or droplets, at more or less regular distances. After a further exposure of a few days, it will be found that all the droplets have increased in size, some having reached a pale sherry colour. Further exposure leads to increase in size, eventually resulting in dimensions about double the diameter of the fibre. The colour changes may be from white to sherry, red, then dark brown, after about six weeks' exposure; later a little irregularity of contour of the brown droplets may be noticed, showing that the liquid is tending to solidify with irregular contraction; fresh deposits may appear in the interspace between old droplets, so that a fibre may contain droplets in all stages.

It is evident that the first liquid product, colourless at the beginning, is soon oxidised in the ozone which is produced by the α-rays. By reason of the time required and the minute quantity of the first product, it is difficult to make tests before oxidation has taken place to some extent.

Preliminary microscopical examination of the final dark brown product, which becomes a strongly adherent scaly deposit, on a mica strip (after nine years), demonstrated that the brown deposit was insoluble in alcohol and chloroform but dissolved in hot water. On evaporation of this solution a brown film was formed which cracked into scales on drying. This film became carbonised on heating, at about the same temperature as a particle of gum acacia, on the same electric hot-plate.

So far, I have not obtained deposits by using α- β- or γ-rays, either separately or in combination. The gaseous emanation of radium seems to be necessary, which points to the probability that the radium products of short period are chiefly concerned in the synthesis, or in facilitating condensation on solids. On this point, and on the physical aspects, further experiments are in progress, but it is very desirable that the chemical examination of the products should be made by others with better facilities than those I possess for dealing with very minute quantities. Possibly increased production may be obtained by increasing the proportion of water vapour and carbon dioxide in the air. I should be very glad to know of any work already done bearing on the subject. Have such products ever been found in the atmosphere? If ultra microscopical, rain may contain some.

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Cephalic Index and Sex.

IN NATURE of March 23, p. 389, I find the statement—in a summary of a paper by Miss R. M. Fleming—that "British women show more development of pigment, brachycephaly, and prognathism than do men."

As to the cephalic index I see quite the same in Arthur Thomson and Randall-MacIver's interesting account of skulls from "The Ancient Races of the Thebaid" (Oxford, 1905); and probably this "more development of brachycephaly" in women is a general law.

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